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(71) We, BOC INTERNATIONAL LIMITED, formerly The British Oxygen Company Limited, an English company, of Hammersmith House, London, W6 9DX, England, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to liquid level gauges particularly, but not exclusively, for liquids of high volatility, such as liquefied gases.

It is known to measure the amount of liquefied gas in a vacuum-insulated vessel by measuring the difference in pressure between the interiors of two pipes, of which one is level with the base of the container, and of which the other is at the pressure of the gas in the ullage space of the vessel. While this system works well, it offers no solution to the problem of measuring the height of the liquid surface in the vessel not already fitted with the lower pipe.

The present invention aims at providing a liquid level gauge which need be fitted only to the neck of a vessel containing the liquid in question.

According to the present invention there is provided a liquid level gauge which is as claimed in the appended claims.

The present invention will now be described by way of example with reference to the accompanying drawing, which is a diagrammatic view, partly in section, of one form of liquid level gauge of the present invention.

The illustrated gauge is particularly useful for detecting the height of the liquid surface of a liquefied gas, particularly liquefied helium. For this purpose the liquefied helium 2 is intended to be stored in a vacuum-insulated vessel 4. The neck 6 of the vessel 4 is closed in a pressure-tight manner by a stopper 8 of a suitable material which is an electrical insulant and of low thermal conductivity.

Extending through the stopper 8 is a tube 10 which is in communication with the ullage space 12 in vessel 4. The other end of tube 10 is connected to a differential pressure gauge 14. The tube 10 conveys a reference pressure to gauge 14, whereas the test pressure is conveyed by a tube 16 which is brazed or otherwise secured to one end of a thin-walled, capillary, tube 18 stainless steel or other metal of low thermal conductively. The capillary tube 18 is thermally insulated from the liquid and gas in the interior of vessel 4 by a sleeve 20 of a suitable plastics material.

Also extending through the stopper 8 is a wire 22 which is secured at its lower end to the lower end of capillary tube 18 in a low-resistance joint. In circuit with the wire 22 is a switch 24 and a battery 26 or other source of electrical heating power. The other side of battery 26 is coupled to tube 16. The electrical resistances of wire 22 and tube 16 are so low that the only significant electrical resistance in circuit with battery 26 is that presented by capillary tube 18.

It will be appreciated that under normal conditions of use the liquid 2 enters tube 18 and rises within it to a height which is the same as, or higher than, the height of the surface 28 of liquid 2. For ease of reference, the vertical distance between surface 28 and the lower end of tube 18 has been given the reference "h". The aim of the present invention is to measure *h*. Knowing *h*; the distance between the lower end of the tube 18 and the stopper 8, and the distance between the stopper and the base of vessel 4, enables calculations to be made simply of the distance from the bottom of the vessel to surface 28, which is the depth required to be measured.

When it is desired to make a measurement, the switch 24 is closed for a short time (a few seconds) so as to heat the capillary tube electrically. The resultant Joule heat then causes at least part of the liquid in the interior of tube 18 to be vaporised. The resultant increase of pressure in the tube expels the rest of the liquid from the interior of the tube until

relatively-stable conditions are reached in which the interface between the vapour in the interior of tube 18 and the liquid 2 is at the bottom end of tube 18. Once these conditions have been reached, which may take only a few seconds, the reading of the differential pressure gauge 14 is taken, from which calculations can quickly and easily be made leading to a value for height *h*. Immediately this figure has been reached, the switch 24 is opened so as to discontinue the supply of heat to the interior of vessel 4.

Other arrangements of feeding the electrical heating current to the capillary tube 18 could be used. Thus, instead of 22, the heating current to the capillary tube could be provided by a second tube coaxial with the tube 18. The space between the two tubes could be evacuated so as to increase the thermal insulation of the heating tube from the liquefied helium 2.

In an alternative arrangement, the electrical heating current could be conveyed to the bottom of the tube 18 by an electrically-insulated wire extending through the interior of the tube. This arrangement would have the advantage that the wire would be in contact only with the vaporised gas, and not with the liquefied gas, when the device was being energised to produce a pressure reading.

It should also be appreciated that other means could be used for thermally insulating the capillary tube 18 from the liquefied gas positioned externally of it.

It will thus be seen that the present invention provides a liquid level gauge for volatile liquids, which gauge needs to be fitted only to the neck of a vessel for the liquid in question, the length of the gauge immersed in the liquid being measured by the increase of pressure necessary to expel all liquid from the interior of a tube projecting into the liquid.

WHAT WE CLAIM IS:—

1. A liquid level gauge for measuring the height of the surface of a liquid in a vessel, including a tube for extending downwards into the liquid for a known distance from a pressure-tight stopper for the neck of the vessel containing the liquid, the tube being of material which will release Joule heat when energised by a source of electrical power; means for supplying electrical power to the tube from short periods when it is desired to measure the height of the liquid surface within the vessel, the amount of power supplied being such that sufficient heat to vaporise or eject by the so produced vapour all the liquid previously contained within the tubs is generated, and means for measuring the resultant increase of pressure in the interior of the tube, which pressure is a function of the length of the tube immersed in the liquid, and hence of the distance from the stopper to the liquid surface.

2. A gauge as claimed in claim 1, in which the tube is capillary tube of stainless steel or other metal of low thermal conductivity.

3. A gauge as claimed in claim 1 or 2 in which the tube is thermally insulated by means of an external layer of a thermal insulation material.

4. A gauge as claimed in claim 1 or 2, in which the tube is thermally insulated by means of an evacuated space between the outer surface of the tube and an outer tube in contact with the surrounding liquid.

5. A gauge as claimed in claim 4, in which the outer tube is used as an electrical conductor connected to the lower end of the capillary tube.

6. A gauge as claimed in any preceding claim 1—3, in which the electrical heating current is conveyed to the bottom of the capillary tube by an electrically-insulated wire extending along the interior of the tube.

7. A gauge as claimed in any preceding claim, in which the stopper also has extending through it a tube in communication with the ullage space in the vessel, the two tubes being connected across a differential pressure gauge adapted to give readings from which calculations can be made of the depth of the liquid surface below the stopper, or from the base of the vessel.

8. A liquid level gauge substantially as described herein with reference to, and as shown in, the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*